it has been shown that, with properly antisymmetrized wave functions, a large component of $Be^{8*}+\alpha$ is available in the C^{12} ground state.[15]

REDUCED WIDTHS

Following the discussion of Butler and Hittmair[16] and assuming a structureless alpha particle, one can estimate the ratio of the reduced widths associated with transitions to the ground and the 2.4-MeV states. This ratio was observed to be 1.5, determined from differential cross sections of the main peaks in Figs. 3 and 5. Reliable values of the corresponding coefficients of fractional parentage (cfp) are not available for comparison; these coefficients have been computed only for single nucleon in both *LS* and *jj* coupling and for two nucleons in *LS* coupling.[17] For three or more nucleons, computing the cfp's by simple iteration of the single-nucleon values[18] is a questionable procedure in view of possible coherence among the intermediate states. Lacking a valid theoretical study, however, we have used the method of iteration to estimate the cfp's for a pickup process ($A=12\rightarrow A=9$), and for a knockout process ($A=12\rightarrow A=8$). In the second case, only those states of $A=8$ which can couple vectorially to a neutron to produce the desired state of Be^9 were considered. The results of these calculations give, for the ratio of $(\text{cfp})^2$ for the 0.0- and 2.4-MeV states, 6.9 for pickup, and 1.1 for a knockout process. The experimental ratio appears to favor the latter.

[15] T. Kanellopoulos, Nucl. Phys. **14**, 349 (1959).
[16] S. T. Butler and O. H. Hittmair, *Nuclear Stripping Reactions* (John Wiley & Sons, Inc., New York, 1957).
[17] H. A. Jahn and H. van Wieringen, Proc. Roy. Soc. (London) **A209**, 502 (1951); A. R. Edmonds and B. H. Flowers, *ibid.* **A214**, 515 (1952); J. P. Elliott, J. Hope, and H. A. Jahn, Phil. Trans. Roy. Soc. London **A246**, 241 (1953).
[18] A. M. Lane, Rev. Mod. Phys. **32**, 519 (1960).

PHYSICAL REVIEW VOLUME 130, NUMBER 4 15 MAY 1963

Decay Energy of Tb^{161}†

P. F. M. Koehler,* L. Slack‡
The George Washington University, Washington, D. C.

AND

N. B. Gove
Nuclear Data Project,§ National Academy of Sciences–National Research Council, Washington, D. C.
(Received 26 December 1962)

The beta decay of 7.1-day Tb^{161} has been studied with a double-focusing magnetic spectrometer. The end point of the highest beta group was found to be 584 ± 6 keV.

INTRODUCTION

End points of the highest energy beta-ray group in the decay of Tb^{161} have been reported at 500 ± 3,[1] 540 ± 5,[2] 550 ± 10,[3] 571 ± 4,[4] and 610 ± 15 keV.[5] The spread in these values is considerably greater than the uncertainties quoted. The present work was undertaken in an attempt to clear up these discrepancies.

PROCEDURE

Enriched Gd^{160} was irradiated for one week in the Oak Ridge Research Reactor. Tb^{161} resulted from the beta decay of Gd^{161}. The terbium was separated by an ion-exchange process using Dowex 50WX-12 cation exchange resin, with α-hydroxy-isobutyric acid as the eluant.[6] The spectrometer source was made by evaporation onto a 1.2 cm$\times$0.2 cm backing of $\frac{1}{4}$-mil aluminized Mylar.

The measurements were made with a double-focusing iron-core beta-ray spectrometer with resolution of 0.8%. An automatic field-regulating system kept the spectrometer field constant to a few parts in 10^4. The energy calibration was performed with *K*- and *L*-conversion lines from Cs^{137} and Ir^{192}. Electron detec-

† Supported by the Evening Star Research Fund.
* Present address: the University of Rochester, Rochester, New York.
‡ Present address: the Division of Physical Sciences, National Academy of Sciences–National Research Council, Washington, D. C.
§ Supported by the U. S. Atomic Energy Commission.
[1] A. Bisi, S. Terrani, and L. Zappa, Nucl. Phys. **1**, 425 (1956).
[2] S. A. Baranov, Yu. F. Rodionov, G. V. Shishkin, and L. V. Christiakov, Zh. Eksperim. i Teor. Fiz. **34**, 1367 (1958) [translation: Soviet Phys.—JETP **7**, 946 (1958)].
[3] R. Barloutaud and R. Ballini, Compt. Rend. **241**, 389 (1955).
[4] W. G. Smith, J. H. Hamilton, R. L. Robinson, and L. M. Langer, Phys. Rev. **104**, 1020 (1956).
[5] P. G. Hansen, O. Nathan, O. B. Nielsen, and R. K. Sheline, Nucl. Phys. **6**, 630 (1958).
[6] A survey of the methods for ion-exchange separations is contained in *The Radiochemistry of the Rare Earths, Scandium, Yttrium, and Actinium*, by P. C. Stevenson and W. E. Nervik (National Academy of Sciences—National Research Council, 1961) NAS-NS 3020.

TABLE I. Beta groups in the decay of Tb^{161}. (The end-point energies in parentheses are based on reference 7.)

Group	Beta end point (keV)	Intensity (%)	logft
1	584±6	10	7.8
2	(509)	66	6.9
3	(452)	24	7.4

tion was by means of a Geiger counter in some runs, an anthracene scintillator in others. In the latter cases, only those electrons were counted which produced pulse heights corresponding in energy to the magnetic field setting.

The measured spectra were corrected for background and for a weak component with end point at 860 keV and half-life consistent with assignment to Tb^{160}.

RESULTS

A Fermi-Kurie plot of the Tb^{161} spectrum is given in Fig. 1. The end point obtained is 584±6 keV. The intensity of the highest energy beta group is relatively low. This fact may have caused the discrepancies in the end-point determinations mentioned above. The major sources of uncertainty in the present experiment were background and Tb^{160} impurity.

The plot shown in Fig. 1 is based on measurements of electron energies alone, and thus does not permit accurate determinations of the end-point energies of the inner beta-ray groups. However, the conversion electron studies of Graham, Geiger, and Ewan[7] suggest 74.6- and 132-keV levels in Dy^{161} which, together with the ground state, are fed by beta decay from Tb^{161}. Within experimental error our data agree with the assignment of beta groups going to the ground state

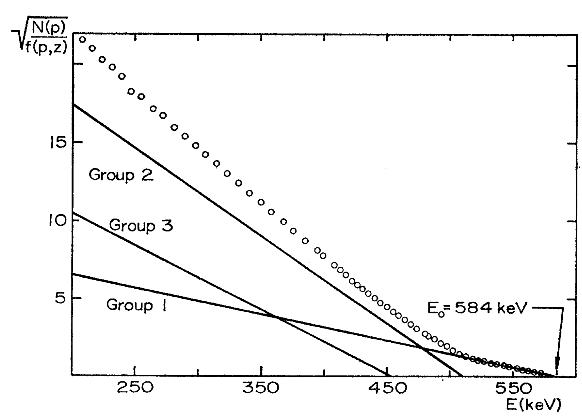

FIG. 1. Fermi-Kurie plot of the beta spectrum of Tb^{161}.

[7] R. L. Graham, J. S. Geiger, and G. T. Ewan, Bull. Am. Phys. Soc. 6, 72 (1961).

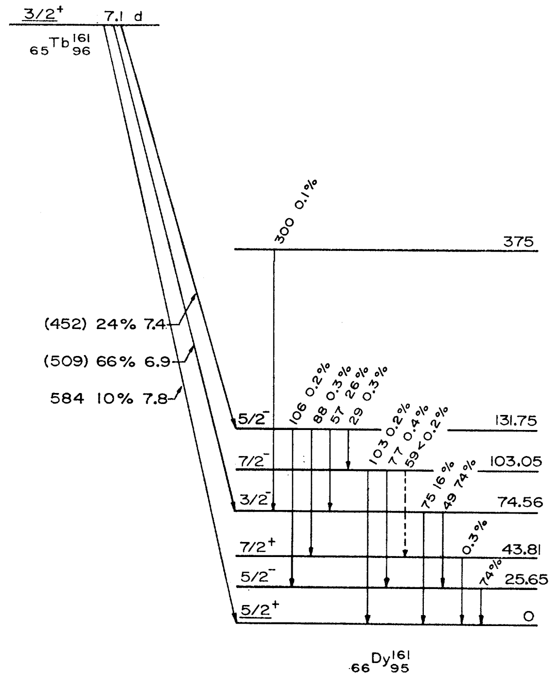

FIG. 2. Decay scheme of Tb^{161}. Only the beta groups are from the present work. The other data are from reference 7.

and to these levels. An analysis of our results with respect to the intensities of these three beta groups gives the values shown in Table I. These beta intensities agree roughly with the intensities needed to feed the various gamma rays. A decay scheme for Tb^{161} is given in Fig. 2 and combines the results of this experiment with those of Graham *et al.*[7]

The ground state beta group is classified as allowed hindered, 3/2 3/2 (411) to 5/2 (642). The logft is 7.8. The beta groups to the $3/2^-$ (521) state and its rotational member $5/2^-$ are first-forbidden with logft of 6.9 and 7.4, respectively. The unobserved group from the 3/2 (411) state to the $5/2^-$ (523) state is first-forbidden hindered. From Fig. 1 an upper limit of 5% is estimated so that logft=8.0. This interpretation is consistent with the discussions of Mottelson and Nilsson.[8]

ACKNOWLEDGMENTS

We gratefully acknowledge our discussions with A. Artna, R. van Lieshout, and K. Way, and the assistance and advice in matters chemical provided by G. D. O'Kelley, T. P. Perros, and W. R. Sager. The spectrometer was made available through equipment loan contract Nonr 2599(00) from the Office of Naval Research.

[8] B. R. Mottelson and S. G. Nilsson, Kgl. Danske Videnskab. Selskab, Mat. Fys. Skrifter 1, 8 (1959).